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Elucidating Mechanisms of Ba and Sr Selectivity in Desmid Green Algae with X-ray Fluorescence Microscopy

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The removal of ⁹⁰Sr from radioactive waste is complicated by the chemical similarity of Ca²⁺, Sr²⁺, and Ba²⁺ cations, which also leads to indiscriminate transport of these ions by most organisms. However, desmid green algae of the genus *Closterium* have the ability to selectively precipitate (Ba, Sr)SO₄ crystals within vacuoles, indicating that they possess a rare mechanism for selectivity of Sr and Ba vs. Ca. Using synchrotron x-ray fluorescence microscopy, we have quantified the uptake and sequestration of Ba and Sr into crystals and have observed time-dependent changes in intracellular Sr concentrations. The kinetics of uptake and efflux of Sr appear to be dependent on external Ca concentrations, and Sr and Ca show similar cellular localization. We conclude that selectivity for Sr versus Ca does not occur at the whole cell level. Instead, high S levels detected in the vacuole suggest a selective precipitation mechanism. We propose a “sulfate trap” model in which high sulfate levels in the vacuole leads to preferential precipitation of (Ba, Sr)SO₄ solid solutions due to their low solubilities relative to CaSO₄. An elucidation of the mechanisms of selectivity in these organisms will enable and inspire innovation of chemical and bioremediation approaches to ⁹⁰Sr cleanup operations.